Form No. 7240C

INSTRUCTIONS FOR ALNOR DEW POINTERS TYPES 7300 AND 7300D

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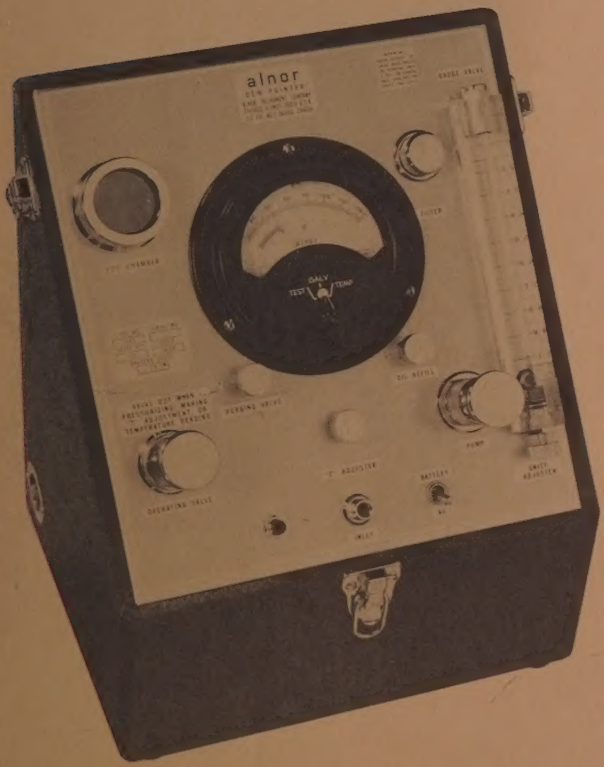

ALNOR INSTRUMENT COMPANY
420 N. La Salle Street
Chicago, Illinois 60610
Area Code 312 467-1331
Telex 25 – 3223

INSTRUCTIONS FOR ALNOR DEW POINTERS TYPES 7300 AND 7300D

TYPE 7300D

FIG. 1

ALNOR INSTRUMENT COMPANY
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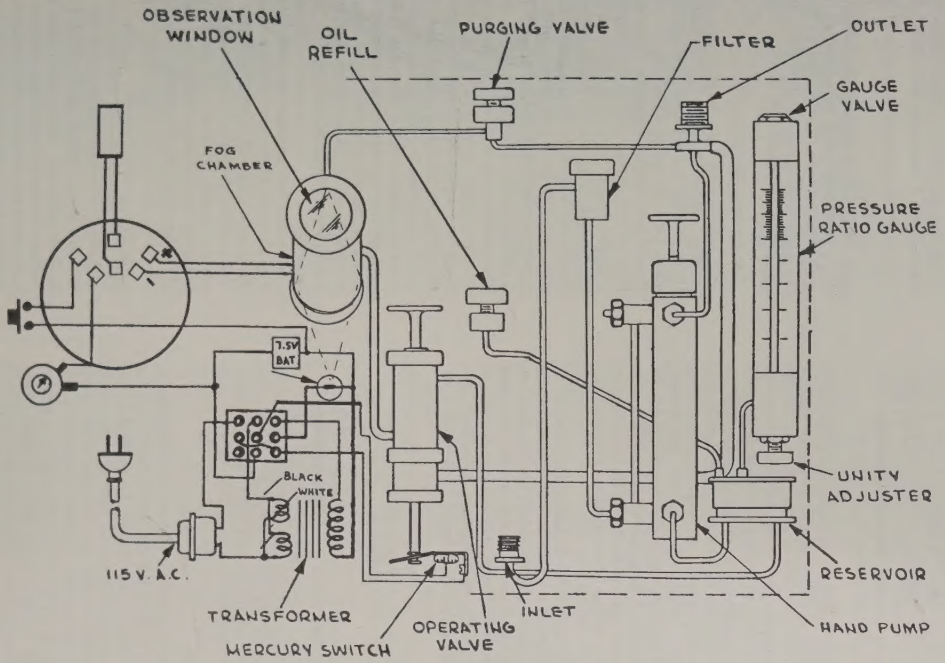

SCHEMATIC DIAGRAM

FIG. 2

INSTRUCTIONS FOR THE OPERATION OF ALNOR TYPES 7300 & 7300D DEW POINTERS

Introduction:

The Alnor Dew Pointers are unusually precise instruments for determining the dew point temperature of air or other noncorrosive gases. The nominal range of measurement is from room temperature down to -80°F but not all models have this full range. Only the Types 7300 and 7300D will be explained in this manual. There is a section beginning on page 7 describing the principle of operation and explaining most of the questions that arise during the operation of the Dew Pointers.

The only difference between the Type 7300 and 7300D is that the latter instrument has provision for the insertion of a variety of scales behind the pressure ratio gauge. This series of scales permits one to read the pressure ratio in the conventional manner or it permits one to insert a selected scale that will provide direct reading of the dew point temperature without reference to the calculator. These special scales that provide direct reading are prepared in three ranges but are applicable only to those gases having a "Q" value of .285. See Table 1. Both of the Dew Pointers being described can be operated from the 115 volt a-c line but they do contain a 7.5 volt battery that may be used to operate the lamp. It always operates the resistance thermometer which measures the temperature of the fog chamber. Connecting the Dew Pointer to the source of gas; purging the instrument; and making the routine preliminary adjustments are so important that great emphasis will be placed upon these operations.

TABLE 1

Scale No.	Ambient Temperature	Range of D.P. Temperatures
1	50° to 120°F	-60°F to 10° below amb.
2	30° to 60°F	-50°F to 10° below amb.
3	60° to 90°F	-30°F to 10° below amb.
4	90° to 120°F	-10°F to 10° below amb.

Preparation:

For the Type 7300D, select the desired scale from Table 1 and insert this scale behind the pressure ratio gauge and fasten it in place with the two screws. Using the line cord provided, connect the Dew Pointer to a receptacle having the voltage shown on the name plate of the instrument. This must be a source of alternating current having a frequency of 50 or 60 Hertz. When no alternating current is available, the instrument may be operated from its own internal battery.

"Z" Adjust:

Turn the meter switch to TEST and if necessary use a small screwdriver to set the meter pointer at "Z" on the scale. Do not press the battery push button at this time.

"T" Adjust:

Press the battery button at the bottom of the panel and turn the ADJUSTER knob to set the meter pointer at "T" on the scale. Release the battery button.

Adjusting the Pressure Gauge:

When using the Type 7300 or the Type 7300D with its No. 1 scale, set the controls as follows:

1. Place the operating valve handle in its outer position.
2. Open the purging valve to be sure there is no pressure within the instrument.
3. Depress the GAUGE VALVE and turn the unity adjuster knob until the bottom of the meniscus of the oil column is at the 1.0 mark.
4. Release the gauge valve.

When using the Type 7300D with one of its direct reading temperature scales, proceed as follows: Turn the meter switch to TEMP and press the battery button. The meter pointer will indicate the temperature within the fog chamber. Release the battery button and see that the scale on the pressure ratio gauge contains the temperature value that has just been measured. If that measured temperature is not found on the scale that had been selected, it will be necessary to choose a different scale to be used under the pressure ratio gauge.

Set the operating controls as follows: Have the operating valve handle out; open the purging valve; close the flow control valve; and then depress the gauge valve. Turn the unity adjuster knob at the bottom of the pressure ratio gauge to bring the meniscus of the red oil column to the observed temperature of the fog chamber. Then release the gauge valve.

In using either of the two Dew Pointers, when it is known that the ambient temperature is changing, frequently measure this temperature and readjust the unity setting or the temperature setting on the pressure ratio gauge. NEVER depress the gauge valve unless the other controls are set as described above.

Connections:

Connect the Dew Pointer to the source of the test gas using an appropriate length of tubing. Recent studies of the moisture adsorption properties of materials have shown that the best tubing to be used in this part of the system is stainless steel tubing. If this is difficult or impossible to obtain, the next best tubing is teflon. All connections must be tight and the pressure admitted to this part of the system must be kept low enough to be safe. If the source of test gas is at a high pressure (more than 8" of water), a pressure reducing valve must be used to prevent damaging the tubing and connections. As a guide to the set-

ting of this valve, it should be adjusted so that the flow of the test gas into the Dew Pointer raises the oil column in the pressure ratio gauge one division when the purging valve has been opened at least one turn.

The outlet of the Dew Pointer may be connected to a suitable discharge tube if desired. This tube must be large enough to prevent the development of any back-pressure.

Operation:

Leave the selector switch on the meter in the "GALV" position at all times unless a "T" adjustment is being made or the initial temperature is being read. The following routine is applicable to either the 7300 or the 7300D when it is provided with its #1 scale.

1. Open the purging valve at least one turn.
2. Pull out the handle of the operating valve.
3. Place the switch in the a-c or BATTERY position depending upon the source of power used. Pump the gas to be tested through the instrument to purge it thoroughly. If the gas is being supplied under a pressure slightly higher than atmospheric, allow it to flow through the Dew Pointer and operate the pump to be sure that all of the tubing in the Dew Pointer is being purged by the gas that is to be tested. If the anticipated dew point is above 0°F, a few minutes spent in purging will dry the instrument and tubing sufficiently to give a reliable indication of the dew point. When the anticipated dew point is below 0°F and possibly down to -70°F it is desirable to purge the complete system for about 20 minutes in order to dry it sufficiently to give a reliable indication of the dew point of the test gas. Having taken the trouble to thoroughly purge the dew point measuring system, it is advisable to keep the system closed when it is not being used so as to prevent ordinary moist air from entering the system.

To obtain a sample of gas that is to be tested, close the purging valve and pump a sample of the gas into the instrument while watching the pressure ratio gauge. If the approximate dew point temperature is known then it is possible to use the calculator to estimate the initial setting for the pressure ratio gauge. If the dew point temperature is not known, one can start with an estimated pressure ratio setting of about .7. Having gotten a sample of gas into the fog chamber, turn the selector switch on the meter to TEMP and press the battery button that is on the lower edge of the panel. The pointer of the meter will indicate the temperature of the gas within the fog chamber. Look into the fog chamber and press down on the operating valve. If a fog appears in the cone of light rays within the fog chamber, it indicates that the gas was cooled below its dew point and subsequent trials will have to be made at a lower pressure. This is indicated by a numerically higher pressure ratio. If a fog does not appear it indicates that the gas was not cooled sufficiently and subsequent trials should be made at a higher pressure. This means a numerically smaller pressure ratio. At this time it should be explained that when the handle of the operating valve is rapidly pushed down, it performs the following operations in sequence:

1. Closes the connection between the pressure ratio gauge and the fog chamber.
2. Turns on the light.
3. Rapidly opens the tube from the fog chamber to the outlet fitting of the Dew Pointer.

After each trial of a sample of gas, it is necessary to open the purging valve; pull out the handle of the operating valve; thoroughly purge the fog chamber and connecting tubing of all moisture that might have been precipitated in these parts of the Dew Pointer; and immediately close the purging valve to prevent atmospheric air and its moisture from re-entering the system. Make other trials at pressure ratios that are suggested by the results of the previous trial.

The object in operating the Dew Pointer is to determine the pressure ratio that will just produce a fog. This is referred to as the "End Point". Having located a pressure ratio that will barely produce a fog and a slightly different pressure ratio that will not produce a fog, it is possible to bring these two pressure ratios closer together to obtain the most accurate estimate of the end point. It should be possible to get the difference between the appearance and the non-appearance of the fog to be only one division apart as indicated on the pressure ratio scale.

When checking for the final determination of the end point, observe the pointer of the meter after pumping the pressure to the expected pressure ratio. It will be noticed that the pointer deflects up-scale slightly as a result of the heat generated during compression. Within a very few seconds the gas within the fog chamber has cooled down to the temperature of the fog chamber as indicated by the return of the meter pointer to its "Z" point. When the stable temperature has been reached, immediately move the selector switch on the meter to its TEMP position and press the battery button. The meter pointer will give the correct measure of temperature within the fog chamber which value is to be used in subsequent calculation of the dew point. Immediately press down the handle of the operating valve and observe whether traces of fog can be detected at the pressure ratio just chosen. It will have been noticed previously that the pressure ratio is retained by the Dew Pointer until the pressure within the system has been released. This permits accurate reading and recording of the end point. The experienced operator will find that he can determine the end point after a few trials since

the density of the fog on any given trial is a valuable clue as to how far he is from the end point. Note that there are only two readings to be taken at the time the end point is obtained. One of these is the temperature of the fog chamber and the other is the pressure ratio.

In performing refined, accurate measurements it is customary to take the mean or the average between the minimum pressure ratio that just failed to produce a fog and the maximum pressure ratio that barely produces a fog. Use this mean value of pressure ratio and the fog chamber temperature along with the "Q" value for the gas being tested to compute the dew point temperature by means of the Alnor dew point calculator.

"Q" Values:

The "Q" value of a gas is a natural constant of the gas or gas mixture. It is representative of the cooling power of the gas. The "Q" value of the gas being tested must be known or accurately estimated to arrive at the dew point temperature of the sample. Values of "Q" for common gases are given in Table 2.

TABLE 2

		Q
Air		.285
Argon	A	.400
Carbon Dioxide	CO_2	.225
Carbon Monoxide	CO	.285
Dissociated Ammonia		.285
Endothermic		.285
Ethane	C_2H_6	.165
Exothermic		.285
Helium	He	.400
Hydrogen	H_2	.285
Methane	CH_4	.240
Nitrogen	N_2	.285
*Oxygen	O_2	.285
Propane	C_3H_5	.139
Other Gases	Refer to chemical h Handbooks	
Gas Mixtures	Refer to the Appendix.	

Use of the Dew Point Calculator:

The newest circular sliderule dew point calculator is designed to permit computation in either Celsius or Fahrenheit degrees.

To use the Dew Point Calculator Form No. 7230B, the following values must be known.

1. Q value of the gas.
2. The initial temperature of the gas as read on the thermometer on the Dew Pointer.
3. The pressure ratio required to just produce a fog.

When "Q" Value is 0.2855

Set arrow 1 at initial temp., °F or °C, on Scale E.
Opposite the observed pressure ratio on Scale D, read Dew Point on Scale E.

EXAMPLE: Air is being tested so the Q value is .2855. The thermometer reads 75°F. A fog appears at a pressure ratio of .46, but does not appear at .47, therefore, the end point is .465.

1. Set the arrow "1" opposite .465 on scale "E".
2. Opposite 75 in scale "D", read the dewpoint temperature of -29.5°F. on the scale "E".

When "Q" Value is not 0.2855

Set arrow 1 at initial temp., °F or °C, on Scale E.
Set arrow 2 at "Q" value on Scale A.
Opposite the observed pressure ratio on Scale B, read Equivalent pressure ratio on Scale C.
Opposite the Equivalent pressure ratio on Scale D, read the Dew Point on Scale E.

EXAMPLE: Pure methane is being tested. The Q value is .24. The initial temperature is 80°F. A fog appears at .51 but does not appear at .52 so the end point is .515.

1. Set arrow "1" at 80°F on Scale E.
2. Set arrow "2" at .24 on Scale A.
3. Opposite .515 on Scale B, read Equivalent pressure ratio as .57 on Scale C.
4. Opposite this Equivalent pressure ratio appearing on Scale D, read Dew Point as 0°F on Scale E.

NOTE: See Appendix for use of the older Calculators, Forms 7230 & 7230A.

Operation of 7300D with Temperature Scales:

Make the "Z" adjustment and the "T" adjustment as described above. Measure the temperature of the fog chamber as described above and select the scale that contains this ambient temperature. Place this scale under the pressure ratio gauge and secure it with two screws. Set the controls as follows:

Operating valve	OUT
Purging valve	OPEN
Flow control valve (if one is used)	SHUT
Gauge valve	DEPRESSED

Turn the unit adjuster knob to bring the red column to the measured fog chamber temperature. Release the gauge valve.

Remember that the direct reading scales are accurate only when used on gases having Q=.285 as listed in Table 2.

Leave the meter switch in the GALV position when it is not required for either of the other two functions. It will then register small differences between gas temperature and fog chamber temperature.

Put the toggle switch in the a-c position if power is available from the line. Open the purging valve; pull out on the operating valve; and adjust the flow control valve, if present, to cause the gauge liquid to rise no more than one division on its scale.

Pump the gas through the Dew Pointer to purge it about 5 minutes if it has had moist air in it and the expected dew point is -30°F or below. Purging is very important at the low dew points (Scales #2 and #3) because moisture given off by the tubing may determine the reading until the tubing is dried.

Close the purging valve and pump a sample into the fog chamber, increasing the pressure until the red column rises up to the anticipated dew point temperature. Look into the observation window and push down on the operating valve. If a fog appears in the "cone of sunbeams", it indicates that the gas was cooled below its dew point and it should be tested again with lower pressures – a shorter gauge column.

If no fog appears that indicates the gas did not cool down to its dew point so it will have to be tested again starting with a higher pressure – longer gauge column. It will be observed that the higher pressures shown by the longer gauge column coincide with lower dew point temperatures on all three temperature scales. Open the purging valve; pull out on the operating valve; for about one minute, operate the pump to purge the chamber.

It may have been noticed that when gas is pumped into the fog chamber the meter pointer moves upscale briefly and when the valve is pressed down the meter deflects downscale. These deflections show qualitatively the temperature changes in the gas due to compression and expansion. They also tell when the gas has returned to the fog chamber temperature.

The goal in using the Dew Pointer is to determine the pressure in the manometer that will just produce a visible fog in the cone of light. This is called the "End Point" which is read as Deg. F. on scales #2, #3, and #4. Having located a pressure ratio that will produce a thin fog and a ratio slightly different that will not, it is usually possible to get the difference between the two points to be 1 division or less on the temperature scale.

When checking the final end point, watch the meter pointer to see it return to Z before pressing down on the operating valve. The operating valve closes the tube between the manometer and the fog chamber; turns on the lamp; and rapidly opens the tube from the fog chamber to atmosphere. It retains the reading on the temperature scale so that it can be observed later and recorded.

If it is likely that the fog chamber temperature has changed since it was last measured, repeat the ambient temperature measurement as described above. If the temperature has changed more than one or two degrees, release all pressure in the system, preferably without letting moist air get into the system, and correct the ambient temperature setting of the manometer. After this, recheck the end point. The final reading of the red gauge column on the chosen temperature scale is the dew point temperature of the gas sample.

With a little practice these manipulations can be performed very quickly. When using Scale #1 refer to **Operation** (on page 5). In sophisticated studies, it is normal to locate the pressure ratio that just produces a fog and one that just fails to do so. The average of these two ratios is taken as the true end point.

Principle of Operation:

The Alnor Dew Pointer operates on a fundamental physical principle that is familiar to all who have observed rain, fog, dew, and moisture condensed on a cold object. When air is cooled sufficiently, moisture will precipitate visibly as drops of water or as fog. The gas to be tested is pumped into the observation chamber at some pressure above atmospheric. The chamber is then rapidly exhausted to the atmosphere with a re-

sultant expansion and cooling of the gas. If the cooling is sufficient to reduce the temperature of the gas to, or below, the dew point, water vapor will condense out in the form of a fine mist or fog. This fog is readily observable thru the chamber window. Because of a light located below the fog chamber focused at the top of the chamber, the fog appears as a cone of sunbeams.

Successive trials will determine the minimum initial pressure which will produce a fog. The gas is then being cooled just to the dewpoint. The final temperature after expansion (the dew point) which is maintained for too brief an interval to measure, is then computed by means of the equation for an adiabatic expansion. The expansion is adiabatic (no heat added or subtracted during the process) because it is so rapid.

The following equation expresses a fundamental relationship between the pressure and temperature during an adiabatic expansion.

$$\text{Final Temp.} = \text{Initial Temp.} \left[\frac{\text{Final Pressure}}{\text{Initial Pressure}}\right]^{\frac{K-1}{K}}$$

where all values are in absolute units and

$$K = \frac{\text{specific heat at constant pressure}}{\text{specific heat at constant volume}}$$

The final temperature thus computed is the dew point temperature in Rankine degrees. The initial temperature is that of the fog chamber as measured from absolute zero. The ratio of the two pressures is that measured by the pressure ratio gauge (P.R.). By definition, the ratio $\frac{K-1}{K}=Q$ which has been mentioned before. For our purpose, the equation of an adiabatic expansion may be written in terms of Faherenheit degrees as follows:

$$^{t}D.P. = (^{t}_{i} - 460)\,(P.R.)^{Q} - 460$$

Since the initial temperature (^{t}i) is read on the thermometer, P.R. is read on the pressure ratio gauge, and "Q" is a constant that depends on the gas being tested, it is apparent that the solution for the dew point temperature ($^{t}D.P.$) is perfectly straightforward through somewhat cumbersome. In actual use, a calculator is supplied that makes the above computation extremely simple.

The formation of a visible fog at the dew point temperature depends on the presence of dust in the gas to act as nuclei around which the droplets can form. In practically all cases dust is present. If, however, gas is completely dust free (such as gas produced by fractional distillation) it would be possible to cool the gas below the dew point temperature without condensing the moisture, if some substitute for the dust particles were not provided. Unless its omission is requested, a very small piece of radioactive material is built into the fog chamber to form ions upon which moisture can precipitate and build up into visible droplets.

SPECIAL NOTICE

This radioactive source can be described as a "fixed sealed source containing 6¼ microcures of Ra 226". Legislatures of some of our states have enacted laws to protect the citizens of their states from indiscriminate use of radioactive materials. Most of these laws contain provisions for licensing, monitoring, registering, and sometimes restricting the amount of material that can be kept on premises. It is recommended that the user learn the applicable regulations from his State Radiation Health Bureau to be sure of compliance. The amount of radioactive material is too small to present a hazard to the user of the Dew Pointer but compliance with the local laws aids continuing accountability of radiating materials within the State. Do not open the fog chamber without specific authority from your State Radiation Health Agency and handling instructions from Alnor. When the need arises to dispose of an old Dew Pointer, the fog chamber should be sent to Alnor or else given to a licensed company that disposes of all radioactive materials.

Operating Notes:

1. When working with dry gases having low dew points, it should be remembered that extremely small quantities of water vapor are involved. It should further be remembered that the instrument can only give the result for the gas sample that is actually in the fog chamber. It is for this reason that it is extremely important that the gas does not pick up or lose moisture in the process of being transferred from its source to the fog chamber.
2. Stainless steel tubing is the best material for connecting the Dew Pointer to the source of gas. Teflon and Tygon are the next choices where flexibility is needed. Other materials require long purging times to free them of adsorbed moisture.
3. A filter is built into the Dew Pointer to remove most of the dirt from the gas but this should be cleaned and repacked when it begins to darken slightly. In sampling a dirty gas, use the in-line filter #7109B to catch most of the dirt. Remember that a dirty filter can add moisture to a gas sample.
4. The built in hand pump is double acting. The gas flowing on the top side of the piston is discharged through the outlet without flowing through the fog chamber. The only function of this gas is to keep the pump barrel dry and avoid contamination of the test gas.
5. Thorough initial purging of the instrument is important. Reference to the vapor den-

sity curves (figs. 7 & 8) show that the vapor density at 50°F. is .59 lbs. per 1000 cu. ft. and the vapor density at -70°F. is only .0019 lbs. per 1000 cu. ft.

If the instrument were originally filled with air having a dew point of 50°F. and only .1% of the original volume were left in the chamber due to inadequate purging the instrument would give an indication that was 3° high when testing a sample of gas having a dew point of -70°F.

Recent studies have shown that moisture adsorbed on the surface of tubing is a source of error at dew points below -30°F unless the tubing is polyethylene, tygon, Teflon, nickel, or stainless steel and they are purged initially for 5 minutes.

To be accurate at -70°F, even the stainless steel should be purged initially for 20 minutes and the system should be closed to exclude atmospheric moisture.

6. It is, of course, important to have all connections tight on the instrument. In some cases mementary negative pressures can be caused in the inlet line by the operation of the hand pump. If there were a leak in the inlet line atmospheric air could flow in and add moisture to the sample during these short periods of negative pressure. Furthermore, the vapor pressure of the air is generally higher than the vapor pressure of the gas being tested. It is, therefore, possible for water vapor to flow in through a leaky connection even when the gas pressure is above atmospheric.
7. If the gas is drawn from a high pressure, as from a bottle of compressed gas, a pressure reducing valve or a needle valve will be needed ahead of the Dew Pointer. A connecting line of adequate size is needed (¼" tubing is suggested; do not use capillary tubing) Do not use an extremely high rate of flow during purging. The use of an excessive flow rate or the use of capillary tubing may cause moisture to be removed from the gas before it enters the Dew Pointer.
8. The above caution does not imply that the flow rate during purging is extremely critical. If the flow rate is such that the oil in the pressure ratio gauge is between .95 and .98 it will be quite satisfactory.
9. The flow rate must, of course, be great enough to back up the hand pump. The pumping action should not pull an appreciable vacuum on the inlet line.
10. Notice that there is a by-pass around the fog chamber thru the top side of the pump. If there is pressure on the inlet side of the Dew Pointer it is quite normal to have a continuous flow from the instrument.
11. If a hazardous or noxious gas is being used it is permissible to connect a discharge line to the outlet of the Dew Pointer. It should be of ample size so that the pressure at the outlet is essentially atmospheric. Do not use a gas that will attack brass or copper.
12. A sample may be drawn from a furnace if the dew point of the sample is lower than the temperature of the Dew Pointer. A ¼" O.D. Inconel tube is suggested for sampling in a furnace. Adequate length for cooling the sample should be included.

APPENDIX

Q Value Of Mixtures

A mixture of gases can be treated as a single gas if the proper constants are established. The value of Q can be computed by one of the following methods.

METHOD 1 - MASS BASIS

Since the effect that the specific heat of an individual gas has on the specific heat of the mixture is proportional to the mass of the gas present the following equation can be written.

(1) $C_{pm} = \frac{M_x}{M_m} C_{px} + \frac{M_y}{M_m} C_{py} + \text{----} + \frac{M_z}{M_m} C_{pz}$

(2) $C_{vm} = \frac{M_x}{M_m} C_{vx} + \frac{M_y}{M_m} C_{vy} + \text{----} + \frac{M_z}{M_m} C_{vz}$

Where

C_{pm} = Specific heat at constant pressure of the mixtures

C_{vm} = specific heat at constant volume of the mixture

C_{vx}, C_{vy}, & C_{vz} = specific heat at constant volume of each gas.

C_{px}, C_{py}, & C_{pz} = specific heat at constant pressure of each gas.

M_m = total weight of the mixture

M_x, M_y & M_z = weight of each gas

Specific heats are expressed in heat units per weight unit per temperature unit such as B.T.U. per pound per ^{o} F.

Then

(3) $K_m = \frac{C_{pm}}{C_{vm}}$

and

(4) $Q_m = \frac{K_m - 1}{K_m}$ or from figure 3

where

K_m = K value for the mixture

Q_m = Q value for the mixture

It is only necessary to insert the proper values in equations (1) and (2) and then solve.

EXAMPLE FOR METHOD 1

A mixture of gas is known to be composed of the following:

20% by weight CH_4
40% by weight CO_2
40% by weight N_2

Find the value of Q

Substituting in equations 1 and 2

$C_{pm} = .2\ (.593) + .4\ (.200) + .4\ (.247) = .2974$

$C_{vm} = .2\ (.450) + .4\ (.155) + .4\ (.176) = .2244$

Then

$K_m = \frac{.2974}{.2224} = 1.337$

and

$Q_m = \frac{.337}{1.337} = .252$

METHOD 2 - VOLUMETRIC BASIS

When a mixture of gases is analyzed with an Orsat apparatus the percentages of each component are determined on a volumetric basis. It is, therefore, essential that these volumetric percentages be converted to weight percentages before Method 1 can be used.

(5) $\frac{M_x}{M_m} = \frac{Xd_x}{d_m}$ $\qquad$ $\frac{M_y}{M_m} = \frac{Yd_y}{d_m}$; etc.

where

X = percent by volume of gas X

d_x = density of gas X

d_m = density of the mixture

Notice that any condition of temperature and pressure and any units of density can be used provided the same conditions and units are used thruout.

Equations 1, 2, 3, & 5 can be combined and multiplied by $\frac{d_m}{d_m}$ to following simple form.

(6) $K_m = \frac{Xd_xC_{px} + Yd_yC_{py} + \text{---} + Zd_zC_{pz}}{Xd_xC_{vx} + Yd_yC_{vy} + \text{---} + Zd_zC_{vz}}$

Where X, Y and Z are volumetric percentages of each gas and d_x, d_y, and d_z are the density of each gas.

Since the values of d_xC_{px} are presented in Table 4 the solution of Equation 6 is extremely simple. Q can be obtained from Figure 3. Because of similarity of values CO, O_2, H_2, and N_2, can be considered one gas.

K TO Q CONVERSION CURVE

FIG. 3

ALNOR INSTRUMENT COMPANY
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Illinois Testing Laboratories, Inc.
420 NORTH LA SALLE STREET
CHICAGO 10, ILLINOIS

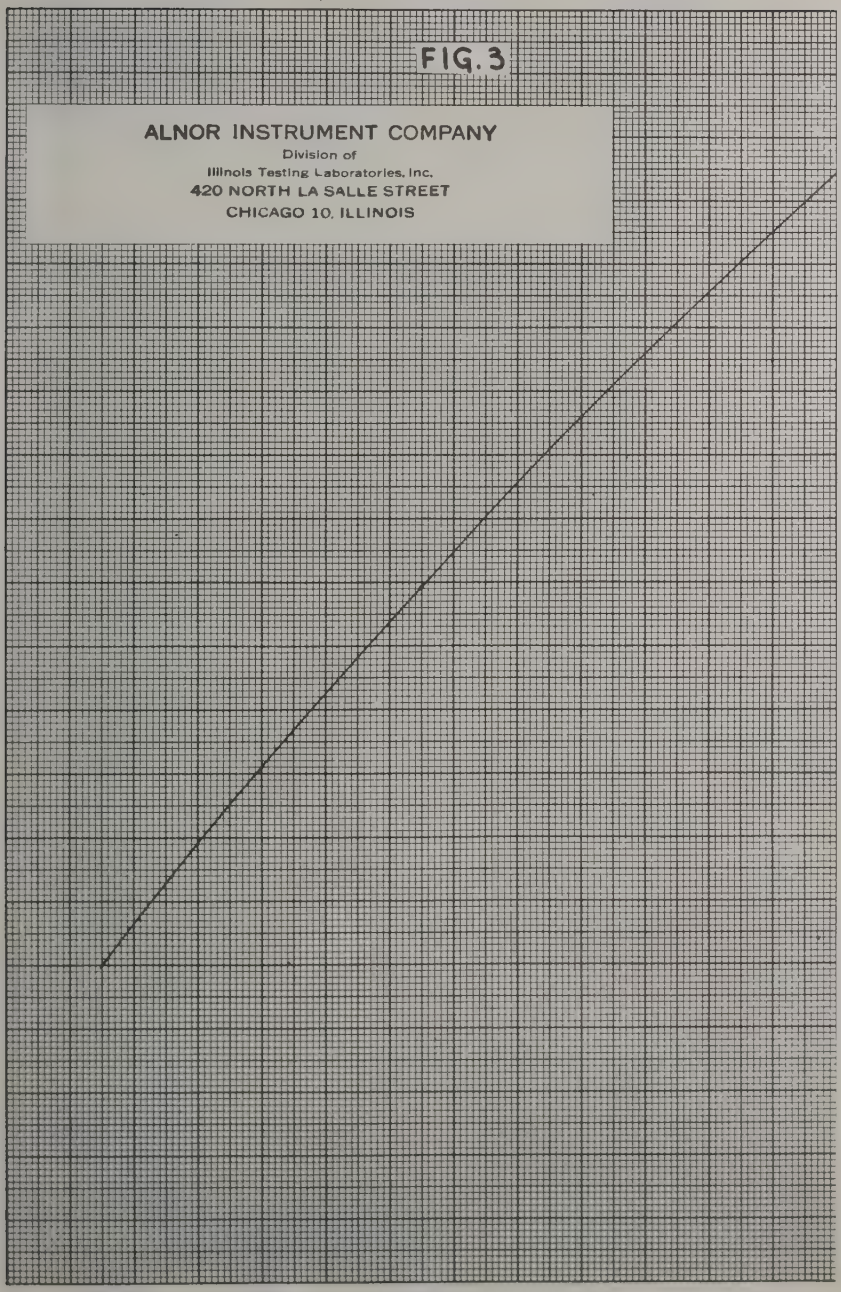


TABLE 3

Gas	Density lbs/ c.f. @62°F.	C_p B.T.U. per lb.	C_v B.T.U. per lb.	$(d)C_p$ B.T.U. per c.f.	$(d)C_v$ B.T.U. per c.f.	K	Q
CO	.0735	.245	.175	.0180	.0128	1.40	.2855
N_2	.0737	.247	.176	.0182	.0130	1.40	.2855
O_2	.0840	.217	.155	.0182	.0130	1.40	.2855
Air	.0757	.241	.171	.0182	.0130	1.40	.2855
H_2	.00529	3.42	2.44	.0181	.0129	1.40	.2855
CO_2	.1156	.200	.155	.0231	.0179	1.29	.225
CH_4	.0421	.593	.450	.0250	.0190	1.315	.240
He	.01114	1.25	.7530	.0139	.0084	1.660	.400
A	.11135	.125	.0751	.0139	.0084	1.668	.400

Notice that all diatomic gases listed can be treated as a single gas for all practical purposes.

EXAMPLE FOR METHOD 2

A mixture of gases is known to consist of the following:

72% by volume N_2

10% by volume of CO

5% by volume of CO_2

12.5% by volume of H_2

.5% by volume CH_4

Find the value of Q

Substituting in equation 6

Gas	Numerator	Denominator
N_2	.72 (.0182) = .01310	.72 (.0130) = .00936
CO	.10 (.0180) = .00180	.10 (.0128) = .00128
CO_2	.05 (.0231) = .00116	.05 (.0179) = .00090
H_2	.125 (.0181) = .00226	.125 (.0129) = .00161
CH_4	.005 (.0250) = .00013	.005 (.0190) = .00010
	.01845	.01325

$$K_m = \frac{.01843}{.01325} = 1.392 \qquad Q_m = .281$$

METHOD 3 - CURVES

A great many commonly used mixtures primarily consist of only one gas other than diatomic gases. For these mixtures values of Q can be picked off of the curves in Figure 4.

The curves in Figure 4 are plotted for mixtures which consist of percentages of the gas named where the balance of the mixture is N_2, O_2, H_2 or CO. If small percentages of other gases are present, they can be ignored.

EXAMPLE - METHOD 3

Given the mixture specified for the example of Method 2 find the value of Q by use of Figure 4.

Since the values of d (C_p) and d (C_v) are so nearly equal for all the diatomic gases assume that they are actually one gas having the characteristics of N_2. Since the volume of CH_4 is small add it to the CO_2 for this purpose, then the analysis of the gas becomes

5.5% by volume CO_2

94.5% by volume N_2

From Figure 4 Q = .281

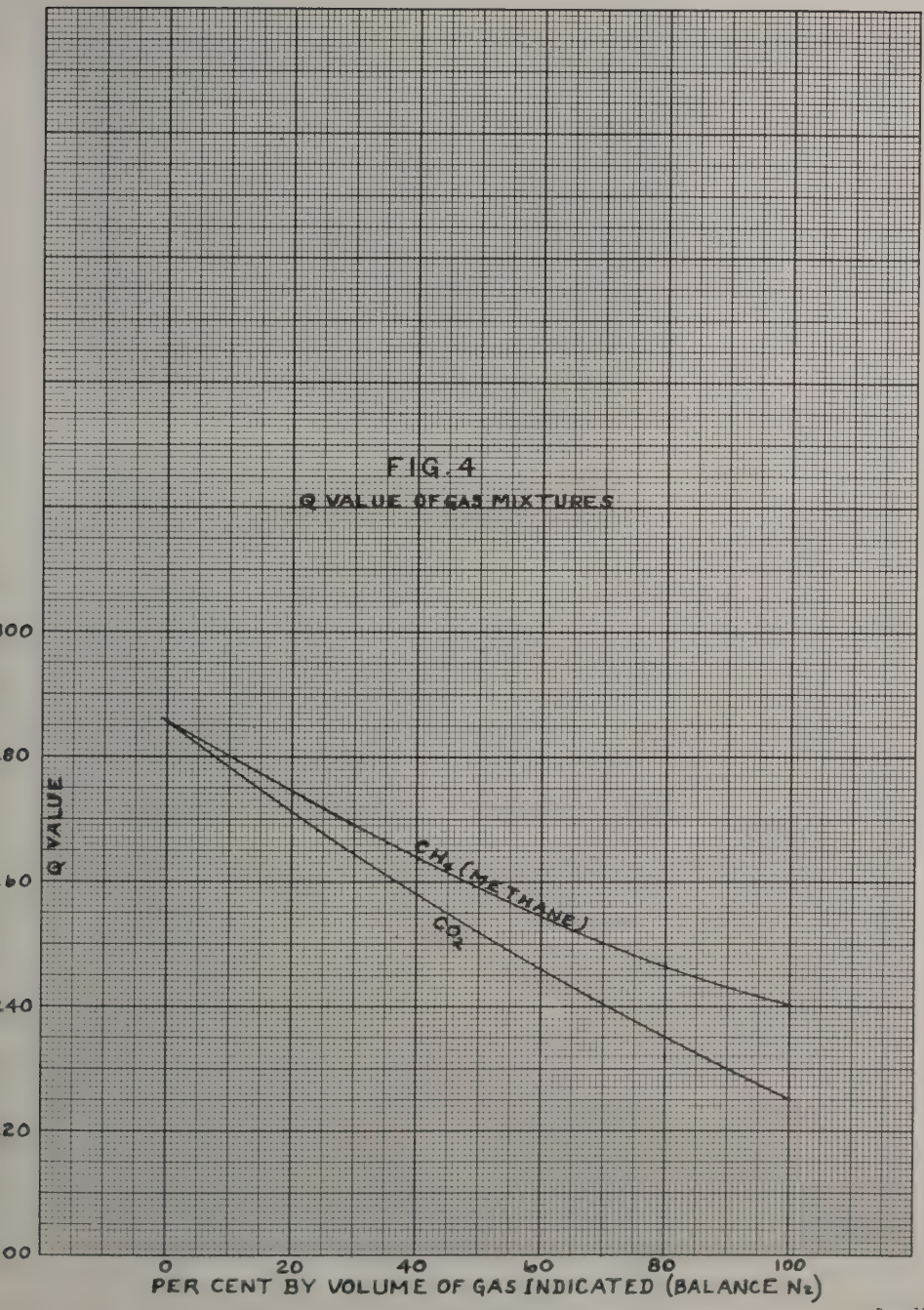


FIG. 4
Q VALUE OF GAS MIXTURES
Q VALUE
CH4 (METHANE)
CO2
00
80
60
40
20
00
0
20
40
60
80
100
PER CENT BY VOLUME OF GAS INDICATED (BALANCE N2)

ACCURACY OF GAS ANALYSIS

An error of .005 in the Q value will produce an error of approximately 2° F. when the pressure ratio is .4; the error will be less for higher pressure ratios. It is, therefore, apparent an error of about 10% in the volumetric analysis of CH_4 or about 7% in the volumetric analysis of CO_2 is generally permissible. It is, therefore, evident that the "Alnor" Dew Pointer is not dependent upon an accurate gas analysis as far as common mixtures are concerned. It is obviously not necessary to make an Orsat analysis prior to each dew point test.

Figure 5 graphically shows the effect of Q value in the dew point determination assuming an initial temperature of 80° F. For comparatively high dew points (above 0° F.) this value is far from critical. For lower dew points the value of Q should be known with greater accuracy.

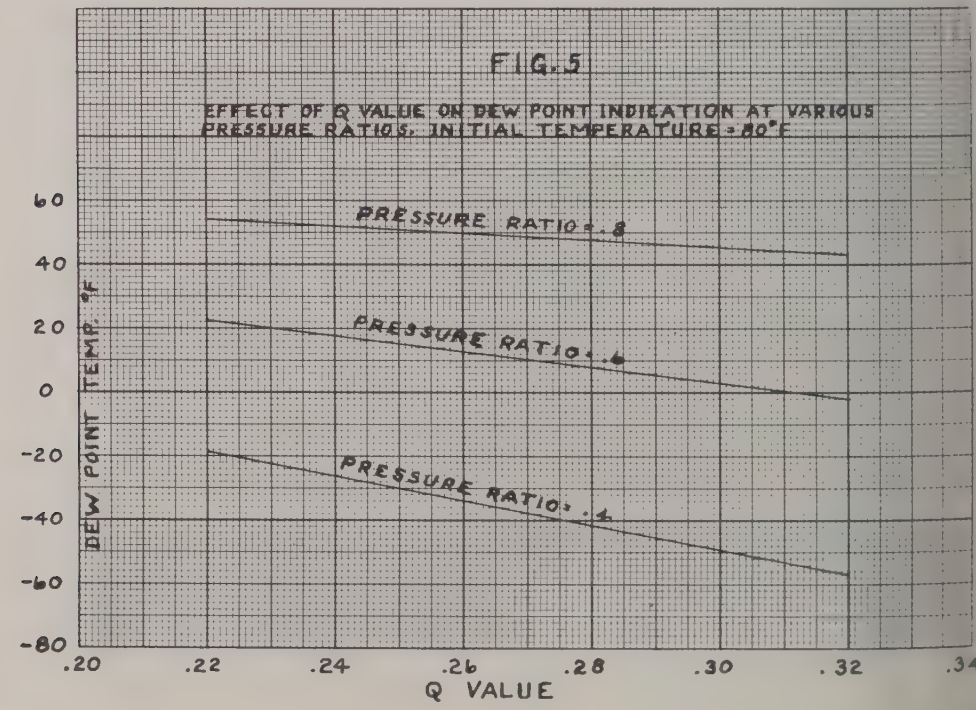
VAPOR DENSITY AND VAPOR PRESSURE

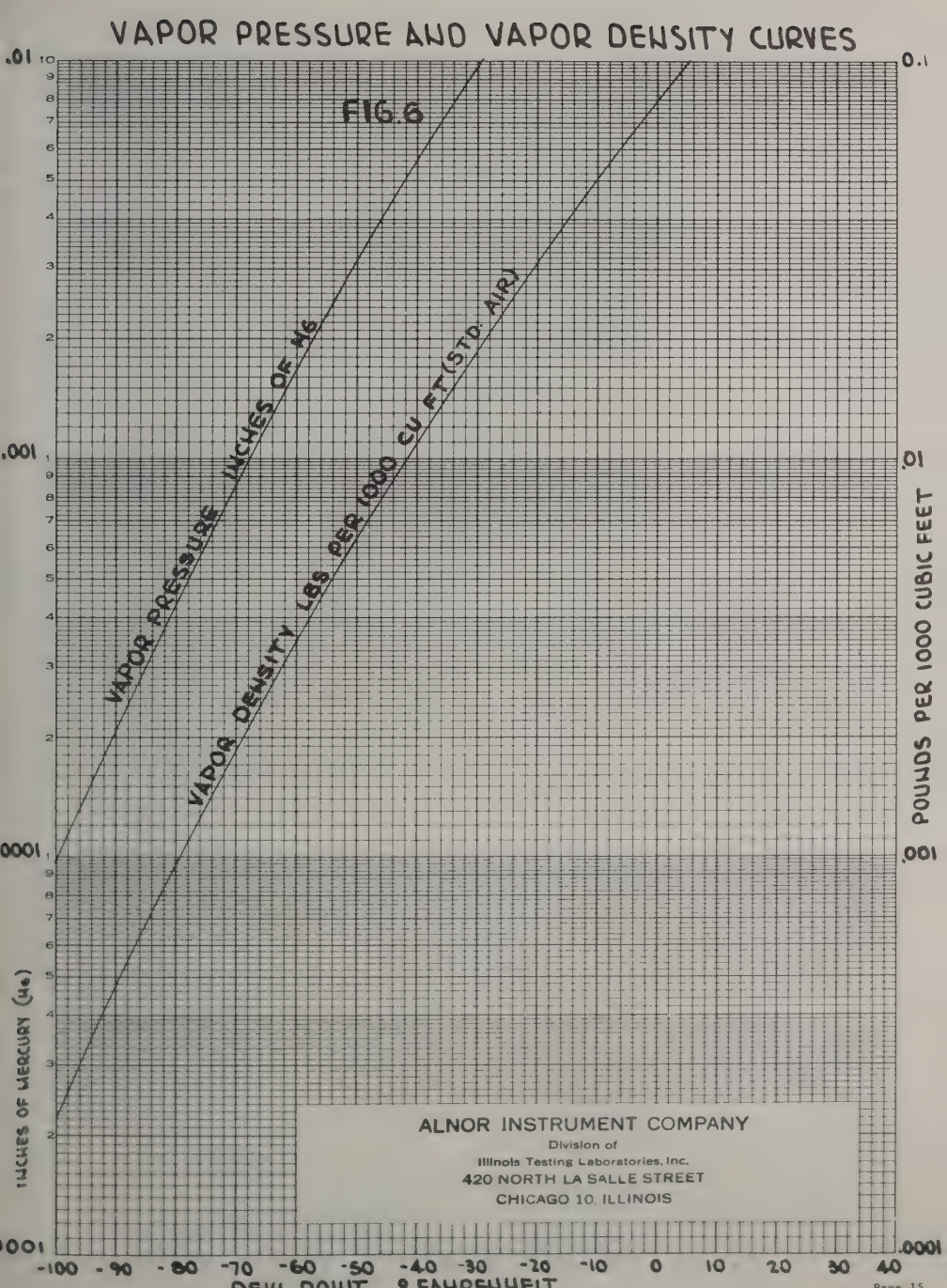
For each dew point there is a corresponding water vapor pressure and water vapor density. The "Alnor" Dew Pointer might just as well have been named a "Vapor Pressure Tester" or "Vapor Density Gauge". The following curves have been provided to permit easy transfer from one set of values to another as the need arises.

For dew points below freezing there are theoretically two possible values for vapor pressure, that is, vapor pressure over ice or vapor pressure over water. There is considerable experimental evidence indicating that the vapor pressure of air corresponds with the vapor pressure of sub-cooled water, whether the air is actually in contact with sub-cooled water or with ice. Accordingly the vapor pressures plotted on the following curves correspond with the vapor pressures over sub-cooled water. Vapor densities are plotted on the same basis.

FIG. 5

EFFECT OF Q VALUE ON DEW POINT INDICATION AT VARIOUS PRESSURE RATIOS, INITIAL TEMPERATURE = 80°F




VAPOR PRESSURE AND VAPOR DENSITY CURVES
FIG.6
VAPOR PRESSURE - INCHES OF Hg
VAPOR DENSITY LBS PER 1000 CU FT (STD. AIR)
INCHES OF MERCURY (Hg)
POUNDS PER 1000 CUBIC FEET
.01
.001
.0001
0.1
.01
.001
.0001
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40
DEW POINT ° FAHRENHEIT
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Division of
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420 NORTH LA SALLE STREET
CHICAGO 10, ILLINOIS

VAPOR PRESSURE AND VAPOR DENSITY CURVES

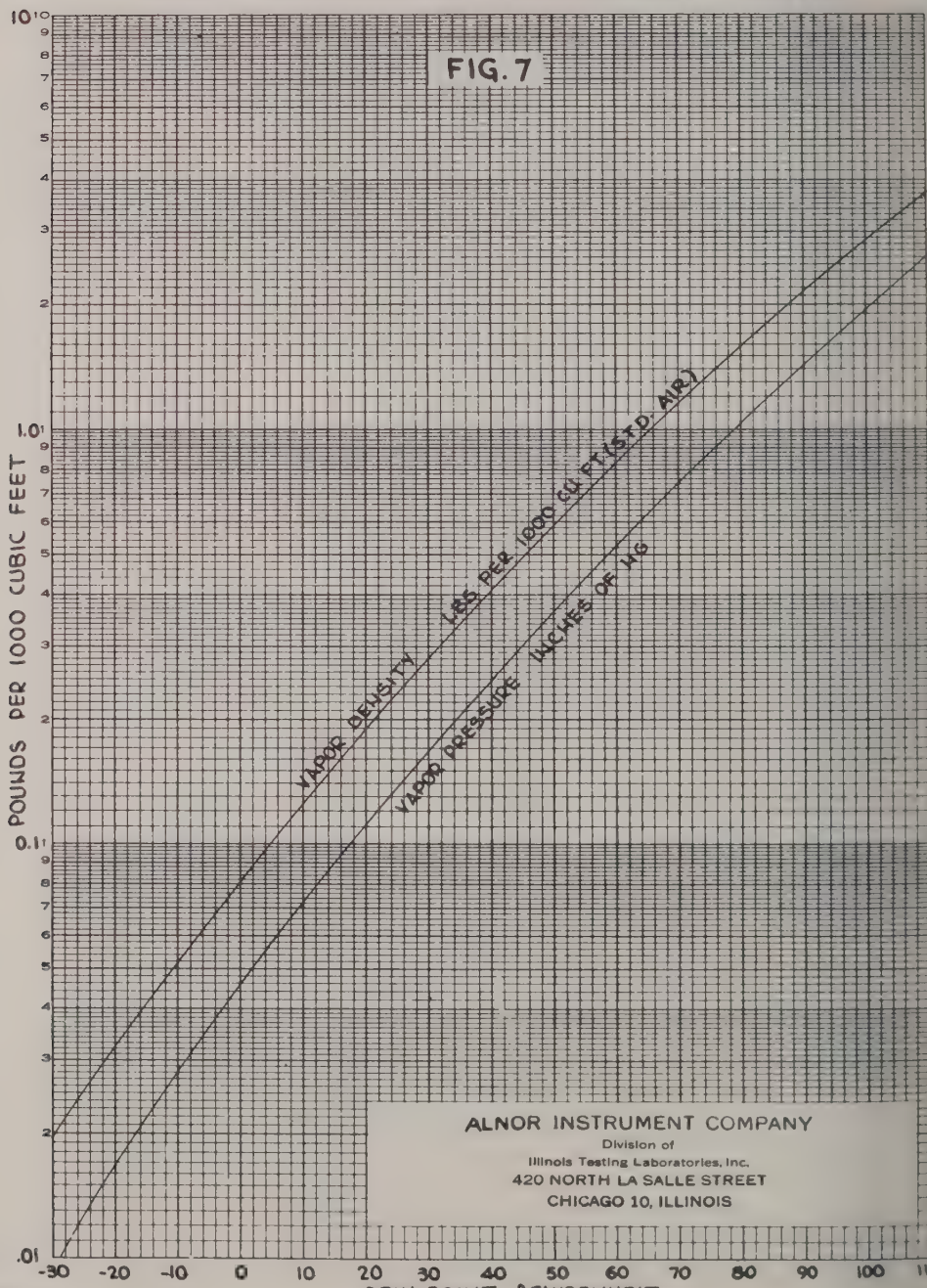


FIG. 7
VAPOR DENSITY LBS. PER 1000 CU. FT. (STD. AIR)
VAPOR PRESSURE INCHES OF H2O
POUNDS PER 1000 CUBIC FEET
10
1.0
0.1
.01
-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110
DEW POINT °FAHRENHEIT
ALNOR INSTRUMENT COMPANY
Division of
Illinois Testing Laboratories, Inc.
420 NORTH LA SALLE STREET
CHICAGO 10, ILLINOIS

THE DEW POINTER AS A "GO, NO-GO GAUGE"

For shop use it is frequently desirable to use the Dew Pointer as a Go, No-Go Gauge. In this case the operation of the instrument becomes so simple that comparatively unskilled workmen can use it.

As an example assume a situation where a gas having a Q value of .2855 is carried in a pipe line at 1 pound gauge pressure. The process is to be operated so that the dew point is kept below 0° F. By performing the operations in reverse order the Dew Point Calculator can be used to develop a chart as follows:

1. Set arrow 1 at initial temperature on Scale E.
2. Opposite max. Dewpoint (Scale E) read pressure ratio (Scale D).

FOR 0° F. DEW POINT

Q .2855

Thermometer	Pressure Ratio Gauge
70	.61
72	.60
74	.59
76	.583
78	.577
80	.57

The instrument can be left connected to the gas line continously with the purge valve cracked so that a small amount of gas is bleeding thru continously. Thus no additional purging would be required. All the operator would have to do is read the thermometer - close the purging valve - pump the instrument up to the indicated pressure ratio - pause for fifteen seconds - and press the operating valve. If a fog appears the dew point is above 0° F.

DEW POINTS AT ELEVATED PRESSURES

If a sample of gas is compressed it is apparent the vapor pressure is increased. The compressed gas, therefore, has a higher dew point that corresponds to the new vapor pressure.

The "Alnor" Dew Pointer gives the dew point at atmospheric pressure. When the corresponding dew point at higher pressures is required refer to Figure 8.

Example: A gas is carried in a pipe line at 585 pound gauge pressure. The "Alnor" Dew Pointer indicates the dew point is -65° F. What is the actual dew point in the pipe line.

Answer is 1° F.

PSYCHROMETRIC CHART

Figure 9 shows the relationship between dew point temperatures, dry bulb temperatures, and relative humidity in the low humidity regions which are difficult to to read on the usual psychrometric chart. The "Alnor" Dew Pointer is particularly useful for making humidity measurements in this comparatively dry region.

Relative humidity is by definition the ratio of the actual vapor pressure of water vapor (the saturated vapor pressure at the dew point) in an air-vapor mixture to its saturated vapor pressure at the dry bulb temperature.

Relative humidity may also be defined as ratio of the weight of water vapor in one cubic foot of the mixture as indicated by its dew point, to the weight of water vapor in one cubic foot of a saturated mixture at the dry bulb temperature.

Example: Dry Bulb Temperature 80° F.
Dew Point Temperature 0° F.

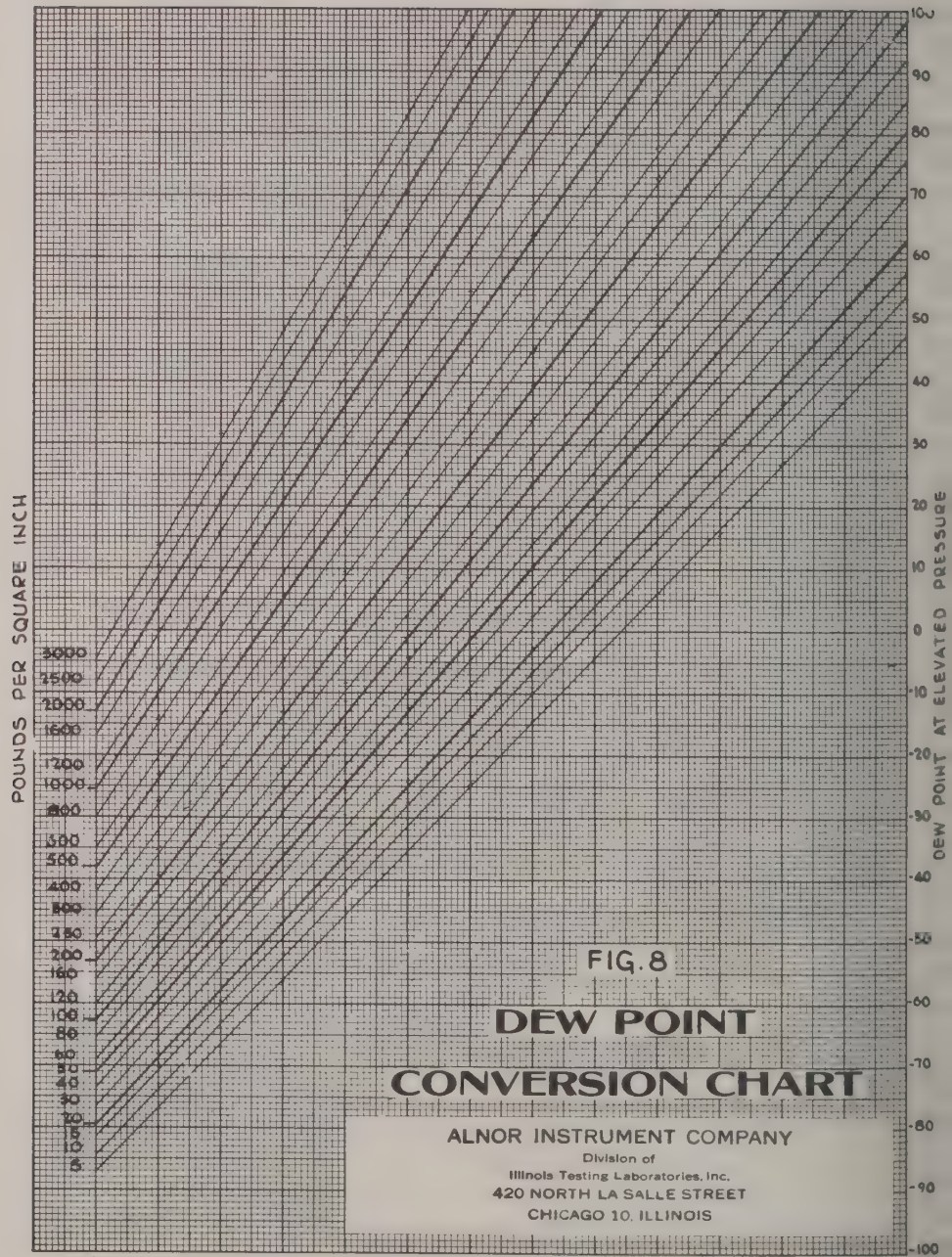
What is the Relative Humidity?
Answer from Figure 9 4.4%

Figure 10 is a standard Psychrometric Chart. In addition to dew point temperatures, dry bulb temperatures and relative humidity, it shows wet bulb temperatures, grains of water vapor per cubic foot, grains of water vapor per pound of dry air and the volume of the mixture in cubic feet of mixture per pound of dry air.

Example: Dry Bulb Temperature 90° F.
Dew Point Temperature 50° F.

What other values can be read from the Psychrometric Chart?

Answer: Wet Bulb Temperature 65° F.
Relative Humidity 25%.
Volume of the Mixture 14.0 per cu. ft. of dry air.
Density of the vapor 4.11 grains per cu. ft.
Weight of the vapor 53.4 grains per lb. of dry air.


POUNDS PER SQUARE INCH
3000
2500
2000
1600
1200
1000
800
600
500
400
300
250
200
160
120
100
80
60
50
40
30
20
15
10
5
DEW POINT AT ELEVATED PRESSURE
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40
INDICATED DEW POINT
FIG. 8
DEW POINT
CONVERSION CHART
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PSYCHROMETRIC CHART

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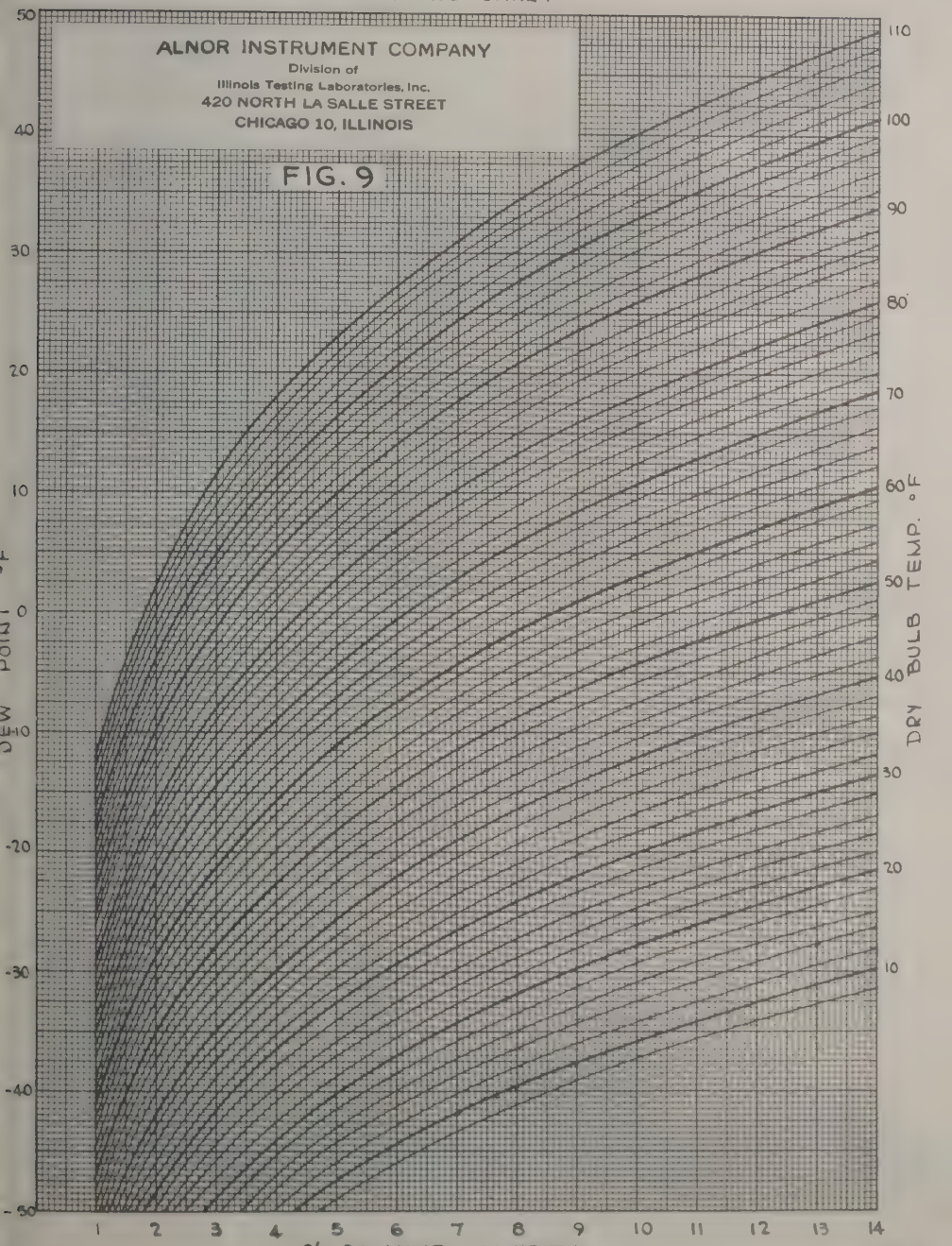
FIG. 9



PSYCHROMETRIC CHART

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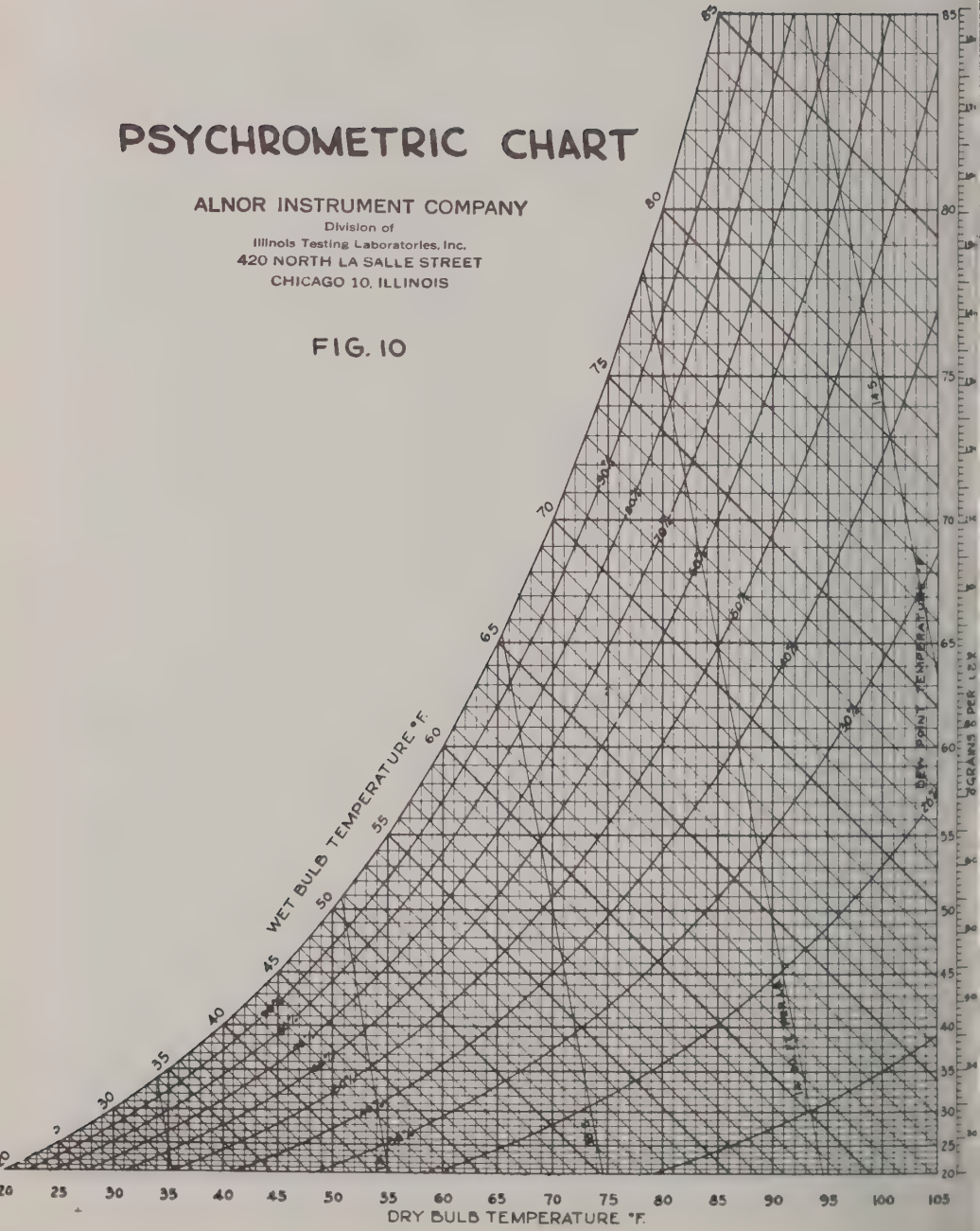
FIG. 10


WET BULB TEMPERATURE °F.
DRY BULB TEMPERATURE °F.
GRAINS OF MOISTURE PER LB. OF DRY AIR
DEW POINT TEMPERATURE °F.
RELATIVE HUMIDITY
SPECIFIC VOLUME CU. FT. PER LB. DRY AIR
ENTHALPY BTU PER LB. DRY AIR

Instructions for the Older Dewpoint Calculators, Forms 7230 & 7230A

The Fahrenheit and Centigrade calculators were separate originally but they have been combined into one calculator now. The name centigrade has been changed to Celsius by international agreement.

Fahrenheit (Form 7230)
When Q is 0.286, set the observed pressure ratio on Scale D opposite arrow 2. READ Dewpoint temperature on Scale E opposite the thermometer temperature on Scale F.

When Q is not 0.286, SET arrow 1 opposite the observed pressure ratio on Scale A. Opposite the correct Q value on Scale C, read the equivalent pressure ratio on Scale B. SET arrow 2 opposite this equivalent pressure ratio on Scale D. READ the Dewpoint temperature on Scale E opposite the thermometer temperature on Scale F.

Celsius (Centigrade) (Form 7230A)
When Q is 0.286, SET arrow 2 at the observed pressure ratio on Scale D. Opposite thermometer temperature on Scale F, read the Dewpoint temperature on Scale E.

When Q is not 0.286, SET arrow 1 at the observed pressure ratio on Scale A. Opposite the correct Q value on Scale C, read the equivalent pressure ratio on Scale D. Opposite the thermometer temperature on Scale F, READ Dewpoint temperature on Scale E.

MAINTENANCE AND SERVICE NOTES

FOR

"ALNOR" DEW POINTERS

Clean and lubricate the "Alnor" Dew Pointer frequently!

1. **Filters** – See Figs. G and H. Check the fiber glass frequently and change it when it begins to darken. Be sure the filter disk and screen are in the internal filter. When testing gas generators, be sure to use the external filter.

2. **Lubrication** – Keep the pump piston lubricated with a good grade of white petroleum (Vaseline). **Do not over-lubricate.** When working with hydrogen the pump piston must be lubricated more frequently.

3. **Bubbles in oil column** – Bubbles in the oil column of the pressure ratio gauge can easily be removed by alternately pumping up the instrument and releasing the pressure. Tilt the instrument forward or to the left during this operation because this will help remove the bubbles.

4. **Refilling Oil Well** – If the oil is accidentally blown out through the gauge valve (see paragraph No. 9, Ratio Gauge) additional oil can be added.

    a. Be sure the purging valve is open, operating valve up (plunger pulled out) and there is no flow to the instrument.

    b. Remove the knurled knob on the filling well and unscrew the needle screw. Use a small screw-driver to fit the filling well.

    c. Place the unity adjuster in its mid position.

    d. Tilt the instrument to the left.

    e. Depress the gauge valve, **and at the same time** add oil by means of the eye dropper provided, until the column comes up to the 1.0 mark. Hold the dropper firmly in the filling well. Release the gauge valve before removing the dropper. Be sure that the needle screw is tightened in place before attempting to use the instrument.

    f. The manometer oil supplied has a specific gravity of .834. Any other grade oil having approximately the same specific gravity can be used because the density of the oil is not a major factor in the calibration of the Pressure Ratio Gauge.

5. **Leaks** – To operate satisfactorily, the "Alnor" Dew Pointer must be free from leaks.

    a. Check all connections. The purging valve can be reseated by tightening the needle point into the seat. Wear on the operating valve packing can be taken up by tightening the top cap. Check the fog chamber window and lens cap.

    b. If after checking all connections and parts, the oil column in the pressure ratio gauge still should drop, the fault may be in the double acting pump.

6. **Pump** – The pump is designed so no outside atmospheric pressure can interfere with the pump action and only the gas to be tested will go through.
   a. The pump is provided with 4 valves (see fig. F). The inlet valve (from filter) and the outlet valve (to operating valve) are the main valves. If dirt or any other foreign particles accumulates in any one of these valves, the pump will not work properly.
   b. To check inlet valve (valve from filter) set oil column to 1.0 mark. Pump 10 full strokes and the oil column should come above .45 mark. If it takes more than 12 full strokes, the diaphragm could be damaged (stretched) or the inlet valve could be faulty. Loosen nut, carefully bend tubing to one side, unscrew valve screw, remove rubber seat, plunger and spring and clean all parts. If any of these parts are damaged, they should be replaced. Placing the parts back again, be sure to follow figure F. The valve screw should be tight.
   c. To check outlet valve (to operating valve) pump up the pressure to approximately .4 mark, observe the oil column, if there is a slow drop of the oil and after depressing the operating valve, even a faster drop, the fault will be in the outlet valve. Proceed in the same manner as on the inlet valve, when replacing the parts again, be sure to follow figure F.
   d. Keep the pump piston and "O" ring lubricated, and if necessary replace "O" ring.

7. **Operating Valve** – The operating valve generally requires little maintenance aside from occasional tightening of the top cap. If it is necessary to disassemble the valve be sure to follow figure C carefully when reassembling. Lubricate all parts with petroleum jelly before reassembling.

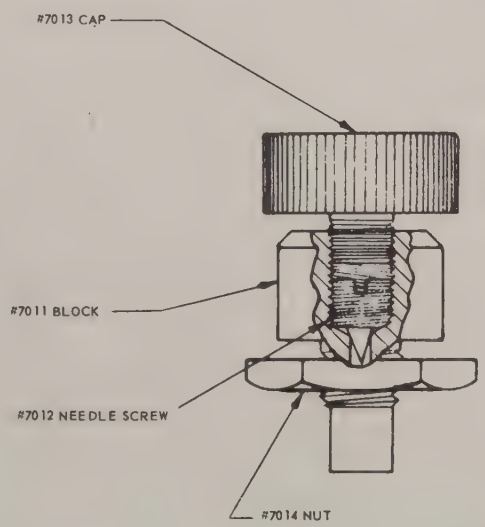
8. **Fog Chamber** – Keep window and lens clean. If necessary replace gaskets. Should the fog chamber become dirty and corroded, the instrument should be sent to the manufacturer for general cleaning, repair and recalibration.

9. **Ratio Gauge** – If the oil is accidentally blown out through the gauge valve, the gauge valve should be washed with naphtha or alcohol. Remove manometer push button by using wrench. To unscrew manometer valve, use two small screw drivers and remove valve. When replacing the valve be sure the "O" ring is in place. Leaks at the unity-adjuster can be corrected by replacing the two "O" rings or the complete adjuster. See figure E. Because of the high coefficient of expansion of the manometer oil frequent readjustment to the 1.0 mark is quite normal if the temperature is changing.

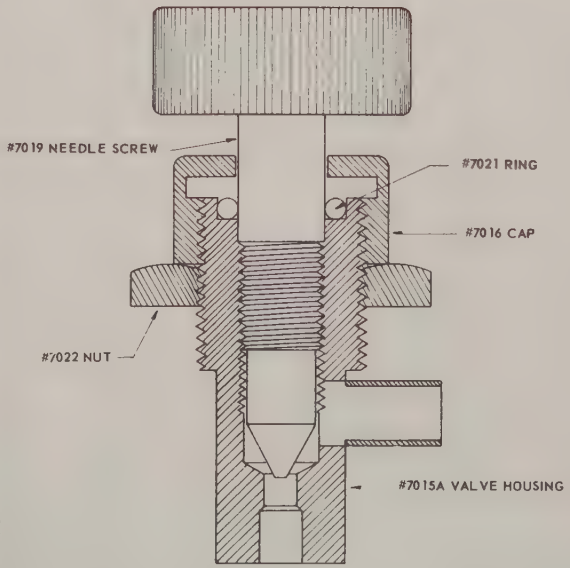
10. **Reservoir** – If diaphragm is damaged (usually stretched) the oil column in the pressure ratio gauge will not come up to the right pressure and excessive pumping becomes necessary and the correct Dew Point can not be obtained. The diaphragm is a Mylar Film. This material is very tough and it is most improbable that a rupture will occur. However depressing the gauge valve when the instrument is under pressure, may stretch the diaphragm. This may also result from pumping when the operating plunger is depressed. If this happens the diaphragm must be replaced. In most of these cases, the instrument should be sent back to the manufacturer for cleaning and repair.

11. **OXYGEN SERVICE** – Special materials are used in Dew Pointers for testing pure Oxygen. Manometer fluid, dibutyl phythalate (Union Carbide Co.) Lubricant, Fluorolube grease GR-362 (Hooker Chemical Co.)
"O" rings in pressure ratio gauge are Parts #7068A, #7086A, #7119B, made of Thiokol (See Fig. E.)

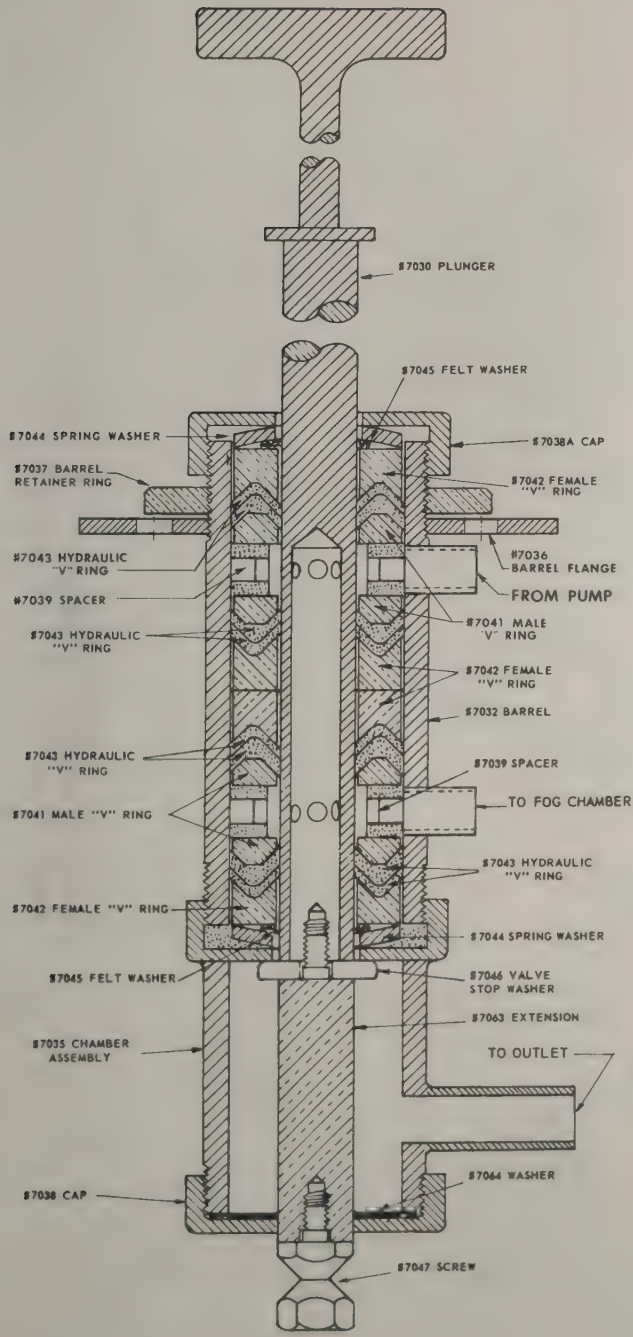
ALNOR INSTRUMENT COMPANY
420 N. La Salle Street
Chicago, Illinois 60610 U.S.A.
312 467-1331
Telex 25 – 3223



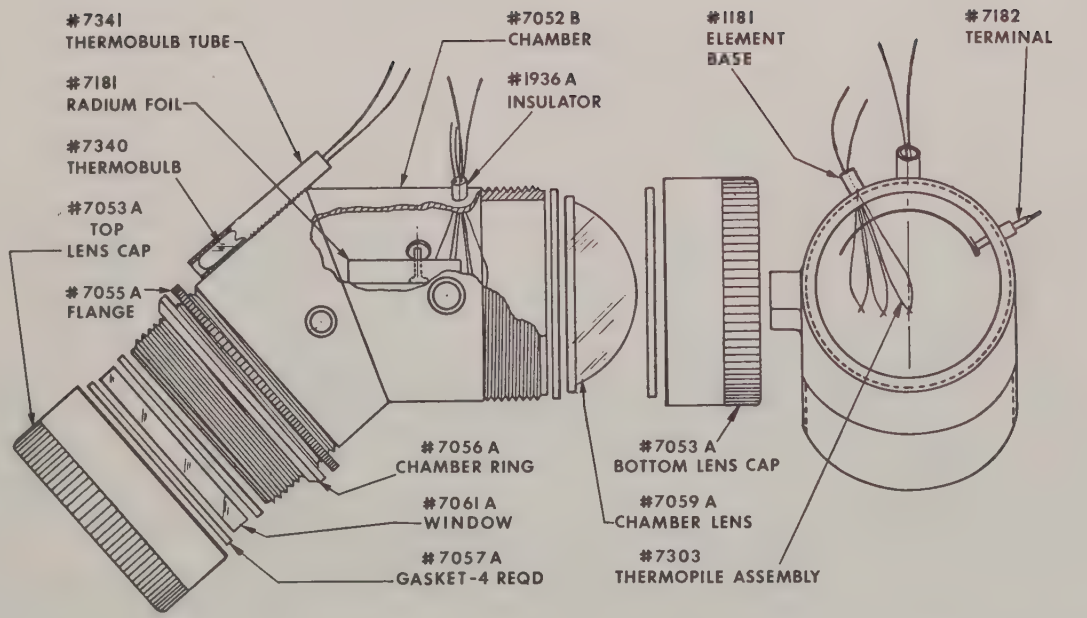
OIL REFILL ASSEMBLY #7010
FIG. A



PURGING VALVE ASSEMBLY #7020
FIG. B



OPERATING VALVE ASSEMBLY #7040
(when ordering, specify type & serial no.)
FIG. C

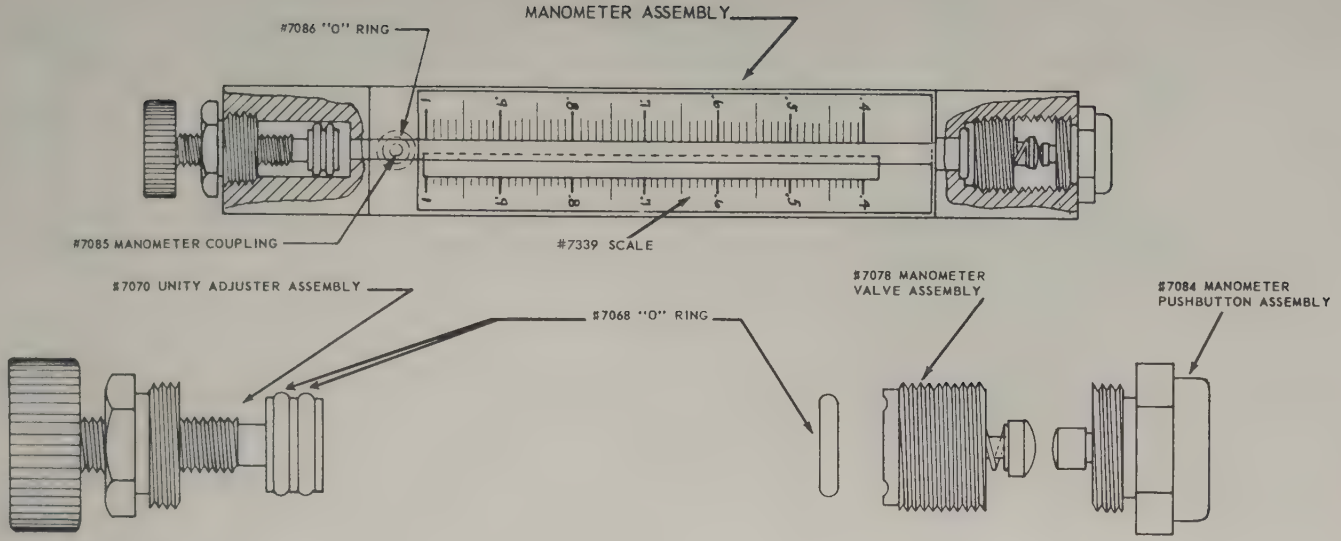


FOR ALL SERIAL NO'S
STARTING WITH 6389

FOG CHAMBER ASSEMBLY #7305

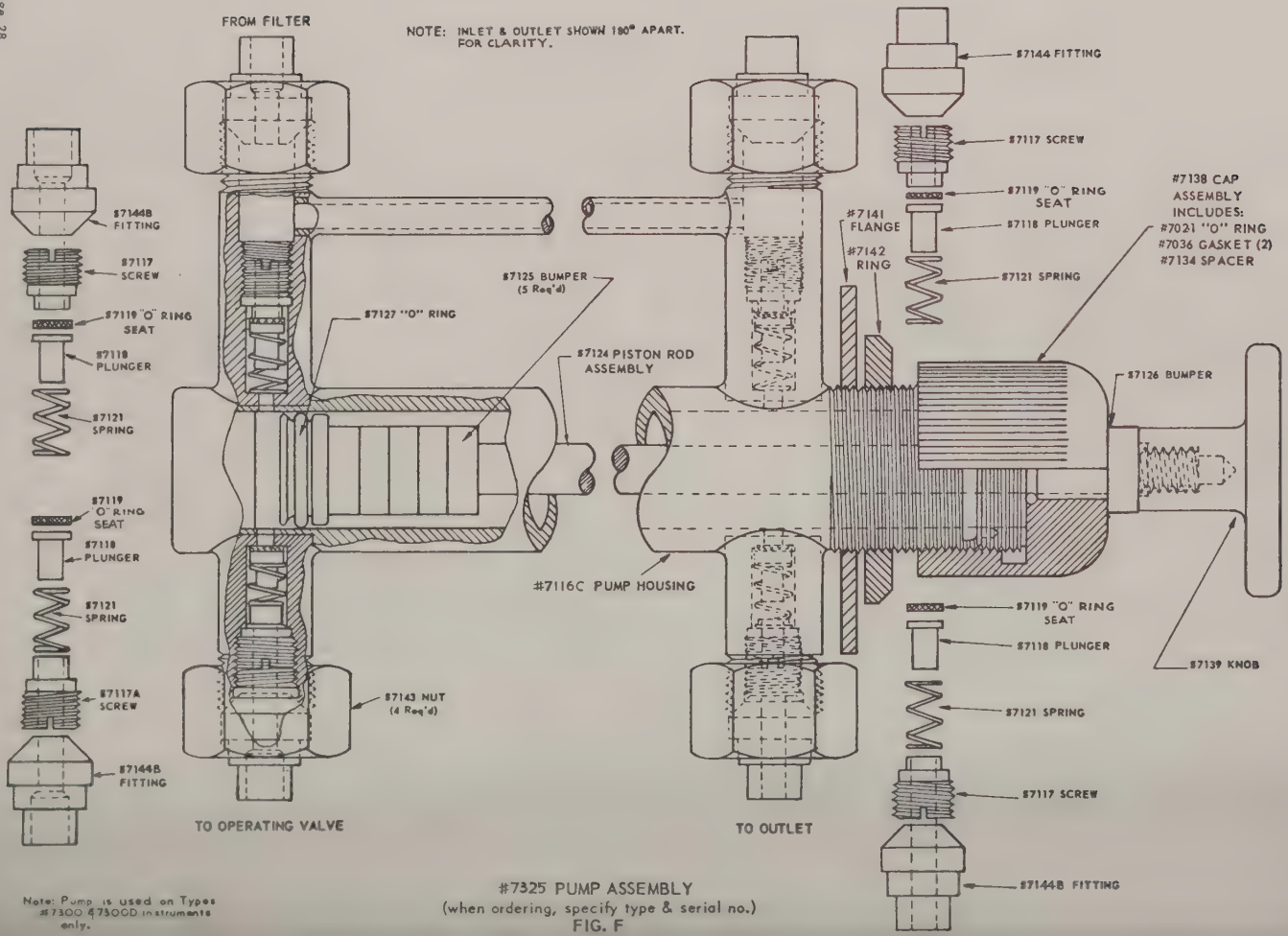
WHEN ORDERING, SPECIFY TYPE & SERIAL NO.

FIG. D



#7320 RATIO GAUGE ASSEMBLY
for Types 7300 & 7350
(when ordering, specify type & serial no.)

FIG. E



Note: Pump is used on Types #7300 & 7300D instruments only.

#7325 PUMP ASSEMBLY
(when ordering, specify type & serial no.)
FIG. F

FIG. G

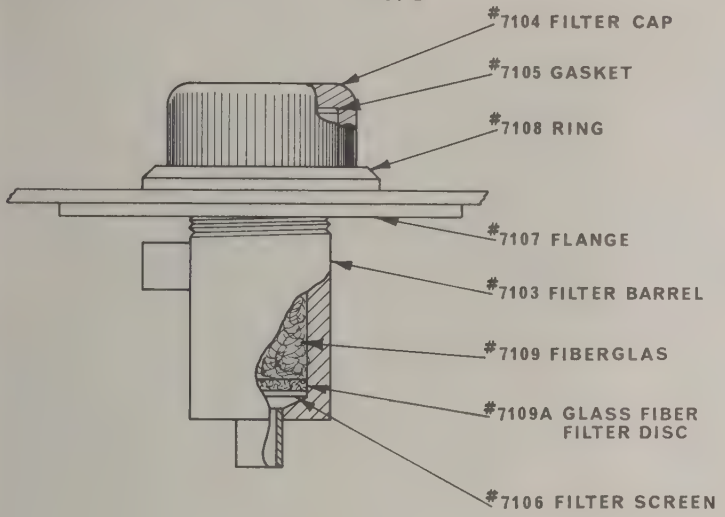
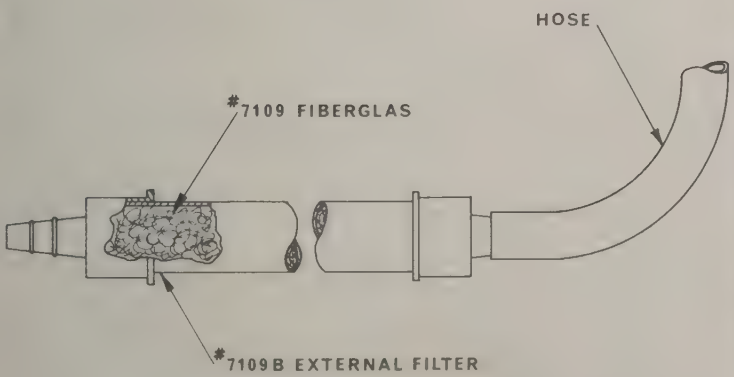

#7104 FILTER CAP
#7105 GASKET
#7108 RING
#7107 FLANGE
#7103 FILTER BARREL
#7109 FIBERGLAS
#7109A GLASS FIBER FILTER DISC
#7106 FILTER SCREEN

FIG. H


HOSE
#7109 FIBERGLAS
#7109B EXTERNAL FILTER

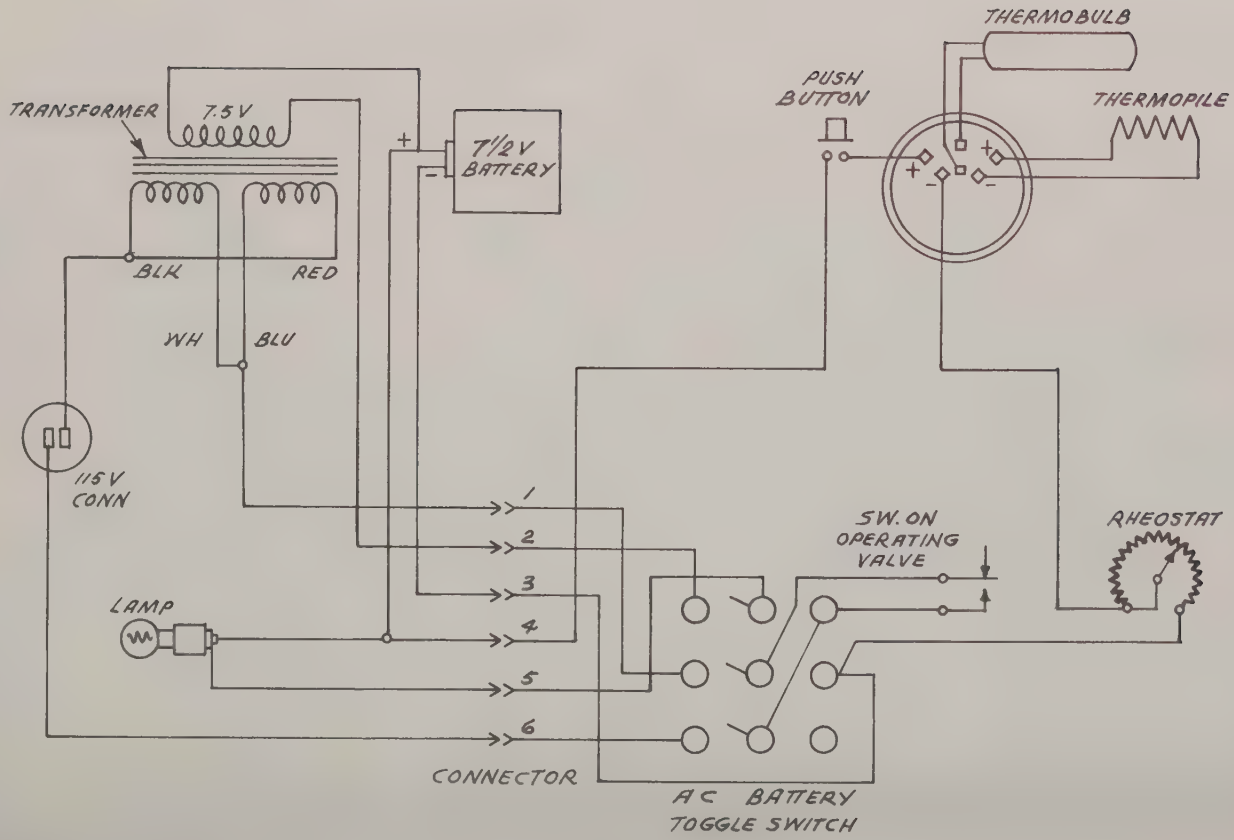
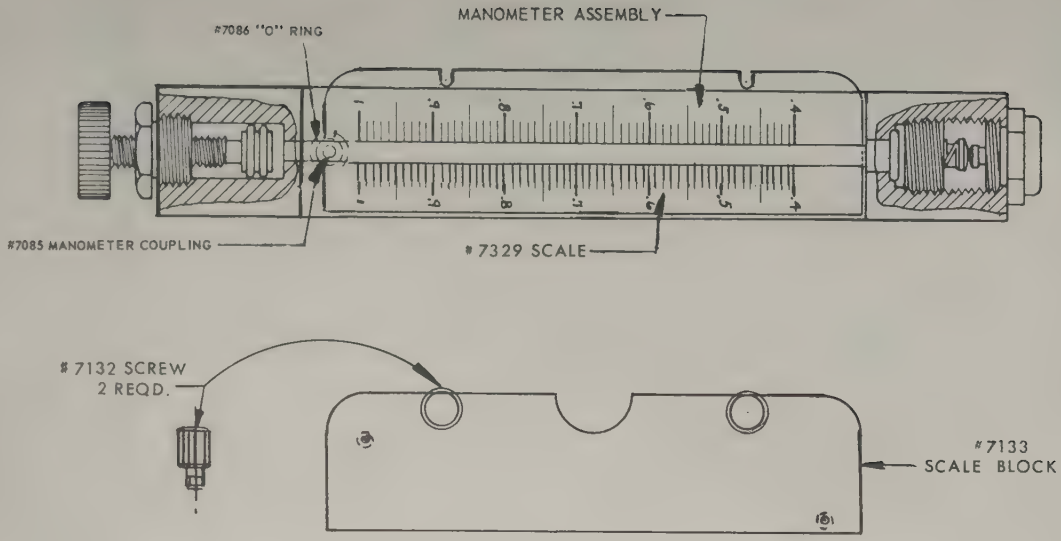

THERMOBULB
PUSH BUTTON
THERMOPILE
TRANSFORMER
7.5 V
7½ V BATTERY
BLK
RED
WH
BLU
115 V CONN
1
2
3
4
5
6
SW. ON OPERATING VALVE
RHEOSTAT
LAMP
CONNECTOR
A C BATTERY TOGGLE SWITCH

FIG. J



#7320 B RATIO GUAGE ASSEMBLY
(when ordering, specify type & serial no.)

FIG. K

#7329
SCALE CARDS
FIG. L

TROUBLE SHOOTING CHART

FOR

"ALNOR" DEW POINTER

OBSERVED DEFECT	PROBABLE FAULT	REMEDY
Oil drops in Pressure Ratio Gauge while under steady pressure	Leaks in system or Leak in pump outlet valve	See Paragraph 5 See Paragraph 6c
Oil rises in Pressure Ratio Gauge while under steady pressure	Leak in Pressure Ratio Gauge Valve	Replace Pressure Ratio Gauge Valve
Pump does not operate freely	Lack of Lubrication	Lubricate pump piston See Paragraph 2
Excessive pumping required	Restriction in supply to Dew Pointer or Diaphragm damaged	Remove Restriction See Paragraph 10
Oil must be replaced frequently	Leak at Unity adjuster	Replace "O" Rings on Unity Adjuster See Paragraph 9

Replace Filter Material Frequently.

PARTS LIST FOR
ALNOR DEW POINTERS,
TYPES 7300 and 7300D

NUMBER OF PART OR ASSEMBLY	DESCRIPTION
7009	INLET FITTING
7010	OIL REFILL (See Figure A)
	7012 Needle Screw only (for 7010) 7013 Cap only (for 7010)
7020	PURGING VALVE (See Figure B) 7016 Cap only (for 7020) 7019 Needle screw only (for 7020) 7021 'O' ring (for 7020) package of 6
7040	OPERATING VALVE (See Figure C)
	7030 Plunger 7032 Valve Barrel 7035 Chamber 7036 Flange 7037 Ring 7038 Cap, plain 7038-A Cap, plated 7039 Spacer, package of 2 7041 Male 'V' ring, package of 8 7042 Female 'V' ring, package of 8 7043 Hydraulic 'V' ring, package of 8 7044 Spring Washer, package of 4 7045 Felt Washer, package of 4 7046 Stop washer 7047 Switch Screw 7063 Extension 7064 Gasket
7305	FOG CHAMBER (Always state Type and serial number of instrument) 7052B Fog chamber housing 7053-A Bottom lens cap 7053-B Top lens cap 7055-A Flange 7056-A Ring 7057-A Gasket, package of 12 7059-A Chamber lens 7061-A Window 7340 T. B. element 7341 T. B. tube
7320	RATIO GAUGE ASSEMBLY FOR 7300

NUMBER OF PART OF ASSEMBLY	DESCRIPTION
7320B	RATIO GAUGE ASSEMBLY FOR 7300D
	7311 Manometer block (7300)
	7311A Manometer block (7300D)
	7133 Block (with screws)
	7068 'O' ring, package of 12
	7070 Unity Adjuster
	7084 Push Button Assembly
	7078 Manometer valve assembly
	7085 Manometer coupling
	7086 'O' ring, package of 12
	7339 Scale assembly (7300)
	7329,a,b,c Scale assembly (7300D)
7101	RESERVOIR ASSEMBLY
	7096 Reservoir
	7098 Reservoir
	7099 Diaphragm, package of 6
7110	FILTER ASSEMBLY (Figs. G & H)
	7109a Filter disk, package of 100 pcs.
	7109b External filter
	7104 Filter cap
	7105 Filter gasket
	7106 Filter screen
7325	PUMP ASSEMBLY (Fig. F)
	7116c Pump housing
7120	SPARE PARTS GROUP FOR 7325
	3 – #7117 check valve screws
	1 – #7117-A check valve screws
	12 – #7118 check valve plungers
	12 – #7119 check valve seats
	12 – #7121 check valve springs
	6 – #7127 piston 'O' rings
	7124 Piston rod assembly
	7125a Piston bumper, package of 2 pcs.
	7126 piston bumper
7138	PUMP CAP ASSEMBLY
	7021 'O' ring, package of 6 pcs.
	7134 Spacer
	7136 Cap gasket package of 6 pcs.
	7139 Pump knob
	7141 Pump flange
	7142 Pump ring
	7143 Fitting nut, package of 4
	7144 Pump fitting
	7144b Pump fitting, package of 6 pcs.

NUMBER OF PART OR ASSEMBLY	DESCRIPTION

MISCELLANEOUS PARTS

7177A 3 pole, D. T. switch
7199A Panel Wiring assembly
7199B Case wiring assembly
7190 Mercury Switch Assembly
7186 Switch spring assembly
7189 Mercury switch

7192 Hose nipple connector with 7143 nut
7193 Tubing nipple connector with 7143 nut
7203 Lamp bracket
7204 Lamp bracket
7205 Lamp socket
7206 6-8 volt lamp, package of 2
7207 lamp protection bracket

7210 Transformer
7211 Battery
7212 Battery male plug
7213 battery bracket
7216 twist-lock base
7219 Plastic tubing (3 feet long)
7220 Connector Cable Assembly
7229 wrench
7230B calculator
7231 manometer oil (4 oz. plastic container)
7235 Filter fiber glass (1 box)

7351 Case for 7300 & 7300D (Specify Serial No.)
7307 rheostat
7309 pushbutton switch
7310 Meter
7199E schematic diagram (Fig. 5)

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